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Investigation of the Thermomechanical Coupling Strength in High-Rate Plastic Deformation Processes

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6. AUTHORS
Murat Vural

5d. PROJECT NUMBER

5e. TASK NUMBER

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7. PERFORMING ORGANIZATION NAMES AND ADDRESSES
Illinois Institute of Technology
Illinois Institute of Technology
3300 South Federal Street
Chicago, IL 60616 -3793

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The views, opinions and/or findings contained in this report are those of the author(s) and should not contrued as an official Department of the Army position, policy or decision, unless so designated by other documentation.

14. ABSTRACT
An advanced understanding of thermoplastic heating process in dynamic deformation events is one of the key steps which not only enhances design and analysis capabilities but also may lead to development of new material systems with unprecedented impact and blast protection performance. The main objective of this project is to develop reliable and repeatable experimental data to serve this purpose and develop predictive models for the fraction of plastic work converted into heat (i.e., thermo-mechanical coupling strength) in dynamically deforming metals. This

15. SUBJECT TERMS
Thermoplastic heating, thermomechanical coupling, high strain rate deformation, high-speed infrared temperature measurement

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a. REPORT	b. ABSTRACT	c. THIS PAGE			Murat Vural
UU	UU	UU	UU		19b. TELEPHONE NUMBER: 312-567-3181

Report Title

Investigation of the Thermomechanical Coupling Strength in High-Rate Plastic Deformation Processes

ABSTRACT

An advanced understanding of thermoplastic heating process in dynamic deformation events is one of the key steps which not only enhances design and analysis capabilities but also may lead to development of new material systems with unprecedented impact and blast protection performance. The main objective of this project is to develop reliable and repeatable experimental data to serve this purpose and develop predictive models for the fraction of plastic work converted into heat (i.e., thermo-mechanical coupling strength) in dynamically deforming metals. This objective has been achieved by integrating high-strain-rate split Hopkinson pressure bar (SHPB) experiments with high-speed IR thermometry measurements, and by establishing repeatable calibration procedures. The results of experiments conducted on a series of alloys, including CP-Ti, OFHC copper (FCC), 1018 cold rolled steel and Al 2139-T8 alloy, have shown that thermo-mechanical coupling strength may evolve as a complex function of strain, strain rate, and deformation history. We have established that dislocation density based strain hardening models lend themselves to satisfactory prediction of thermo-mechanical coupling strength factor for most material systems with the exception of 2139-T8 aluminum alloy. The alloy 2139-T8, which is a newly developed aluminum alloy with promising properties to use in armor applications, has repeatedly showed that fraction of plastic work converted to heat is smaller than other alloy systems, and unlike other alloys this fraction does not reach to 0.9-1 interval but rather stays below 0.6 even at large plastic strains.

List of papers submitted or published that acknowledge ARO support during this reporting period. List the papers, including journal references, in the following categories:

(a) Papers published in peer-reviewed journals (N/A for none)

M. Vural and J. Caro, "Experimental analysis and constitutive modeling for the newly developed 2139-T8 alloy", Materials Science and Engineering A, 520: 56-65 (2009)

Number of Papers published in peer-reviewed journals: 1.00

(b) Papers published in non-peer-reviewed journals or in conference proceedings (N/A for none)

Number of Papers published in non peer-reviewed journals: 0.00

(c) Presentations

"Experimental analysis and constitutive modeling of the thermo-mechanical response of Al 2139 alloy at high strain rates", Invited talk, Aluminum for Defense Applications Workshop, Organized jointly by the U.S. Army Research Office (ARO) and Army Research Labs (ARL), Baltimore, MD, May 3-4, (2010).

"Temperature and rate dependent mechanical response of 2139-T8 alloy", Invited seminar talk, The Center for Impact Physics - Weapons and Materials Research Directorate, U.S. Army Research Laboratory, Aberdeen Proving Ground, MD, August 4, (2009).

Number of Presentations: 2.00

Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Number of Non Peer-Reviewed Conference Proceeding publications (other than abstracts): 0

Peer-Reviewed Conference Proceeding publications (other than abstracts):

E. Eren and M. Vural. "Investigation of the thermomechanical coupling strength in titanium alloys". Proceedings of the 3rd International Conference on Recent Advances in Space Technologies (RAST 2007), June 14-16, 2007, Istanbul, Turkey. doi:10.1109/RAST.2007.4283964

Number of Peer-Reviewed Conference Proceeding publications (other than abstracts): 1

(d) Manuscripts

Y. Xiao and M. Vural, "Investigation of thermomechanical coupling strength in metals via high-strain-rate adiabatic experiments", to be submitted to Acta Materialia. (~September 2010)

Number of Manuscripts: 1.00

Patents Submitted

Patents Awarded

Graduate Students

NAME	PERCENT_SUPPORTED
Erhan Eren	1.00
Jahir Caro	1.00
Yi Xiao	1.00
FTE Equivalent:	**3.00**
Total Number:	**3**

Names of Post Doctorates

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Names of Faculty Supported

NAME	PERCENT_SUPPORTED	National Academy Member
Murat Vural	0.08	No
FTE Equivalent:	**0.08**	
Total Number:	**1**	

Names of Under Graduate students supported

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period:	0.00
The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:.....	0.00
The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:.....	0.00
Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):	0.00
Number of graduating undergraduates funded by a DoD funded Center of Excellence grant for Education, Research and Engineering:	0.00
The number of undergraduates funded by your agreement who graduated during this period and intend to work for the Department of Defense	0.00
The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields:	0.00

Names of Personnel receiving masters degrees

NAME
Erhan Eren
Jahir Caro
Yi Xiao
Total Number: 3

Names of personnel receiving PHDs

NAME
Total Number:

Names of other research staff

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Sub Contractors (DD882)

Inventions (DD882)